



**PRODUCT DEVELOPMENT FOR OUT-  
OF-AUTOCLAVE (OOA)  
MANUFACTURE OF AEROSPACE  
STRUCTURES**

**Steve Mortimer, Matthew J. Smith  
Hexcel  
Duxford, Cambridgeshire, UK**

**Elizabeth Olk  
Hexcel  
Dublin, California, USA**

# Overview

---

- **Why use the OOA process ?**
- **Benchmarking of Existing Products**
  - Matrices
  - Fabric styles
- **Development of an OOA prepreg (M56)**
  - Requirements
  - Processing
  - Performance
  - Demonstrator parts
- **Next Generation Developments**
- **Summary**

# ***Why Out of Autoclave?***

---

- **Significant increase expected in composites used in aircraft manufacture over the coming years**
  - Boeing 787
  - Airbus A350
- **Autoclave capacity**
- **Ovens are lower capital investment**
- **The cost benefit to the customer ?**
  - Materials and processes are the same
  - Reduced tooling costs
  - Lower temperature cure
- **Reliable inspection**
  - Modern ultrasonic inspection methods can assure part quality

# ***OOA Development – Product Requirements***

---

## ➤ **Acceptable Porosity Levels**

- Secondary structure < 2%
- Primary structure - < 0.5 % ?

## ➤ **Cure –ply thickness**

- Similar to Autoclave

## ➤ **Mechanical performance**

- Same as equivalent autoclave prepregs

## ➤ **Processing**

- Good tack / handling
- Similar lay-up / bagging to standard prepregs
- Must be capable for automated process (ATL/AFP)

## ➤ **Product format**

- UD (134 – 268 gsm), woven (193PW-), RFI

# ***M56 Product Development***

---

## ➤ **Product**

- Resin
- Reinforcement

## ➤ **Process**

- Bagging
- Cure cycle

## ➤ **Performance**

# ***M56: Product Forms***

---

## **UD carbon tape:**

M56/35%/UD134/AS7-12K

M56/35%/UD268/IMA-12K

M56/35%/UD268/AS7-12K

M56/35%/UD268/IM7-12K

Product forms can be tailored to suit ATL / AFP presentation

## **Woven Fabric**

M56/40%/280H5/AS4-3K

M56/40%/193PW/AS4-3K

## **Woven glass:**

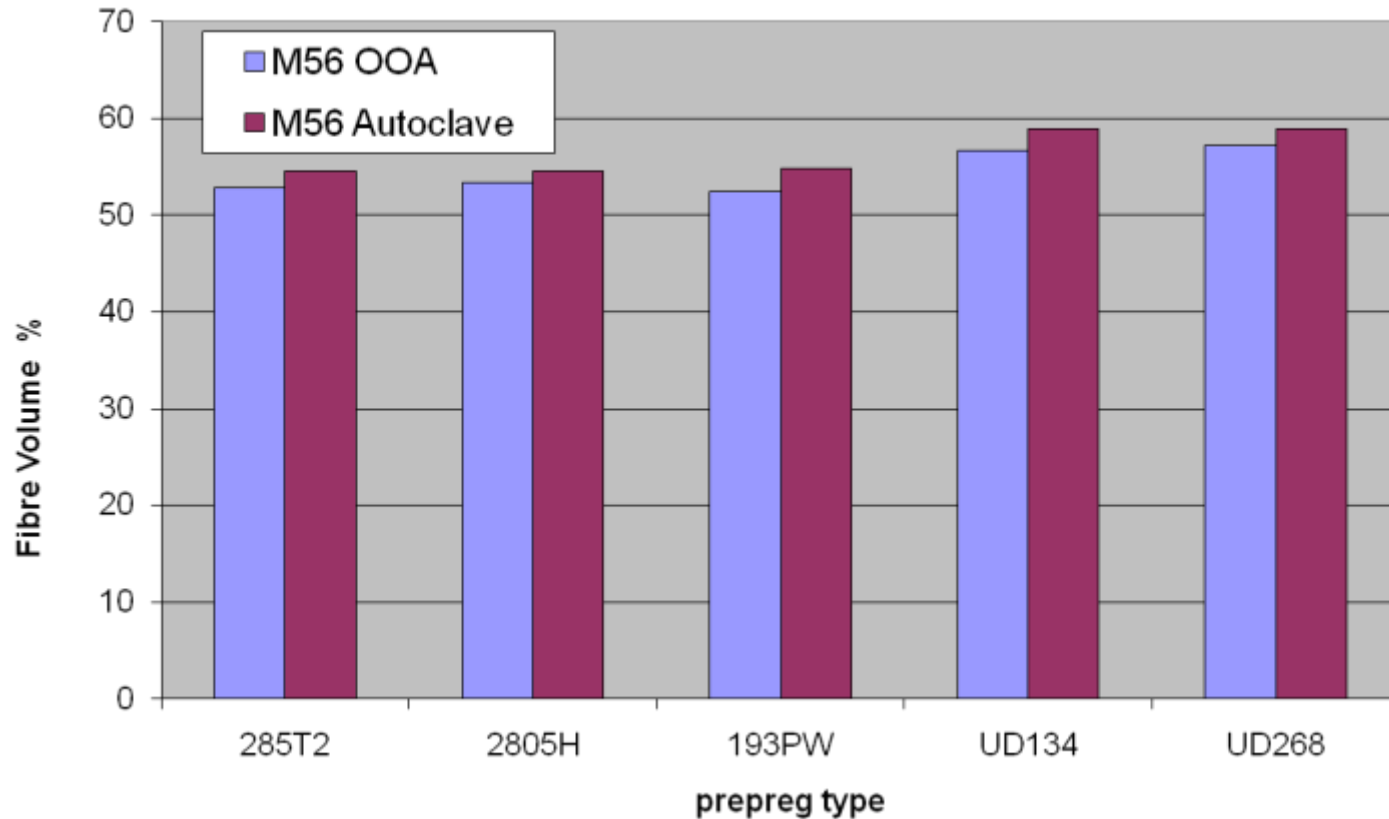
M56/37%/7581 (8 HS weave)

M56/37%/120 (4 HS weave)

## **Bronze mesh**

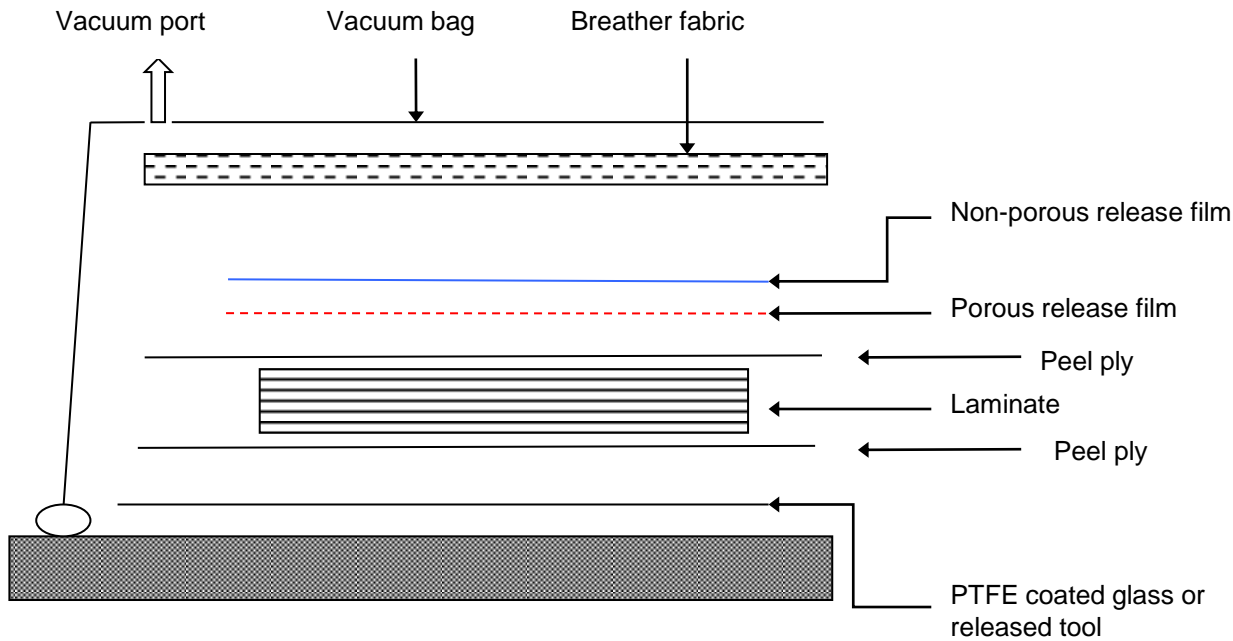
- M56/38%/BZ80 (80gsm Bronze mesh)

# Fibre Volume Vs Product Type



**Products optimised to achieve comparable fibre volume to autoclave cure**

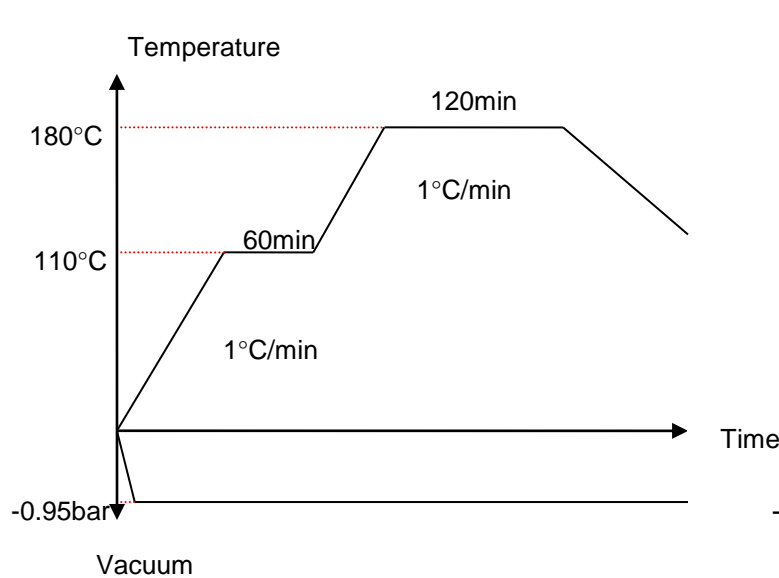
# M56 Processing: Bagging



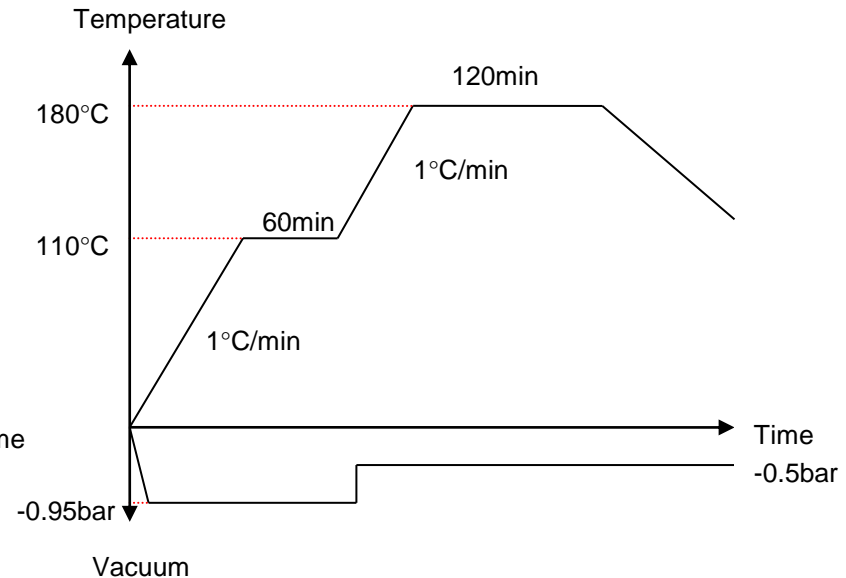
Optimum OOA bagging – surface breathing to remove air



# M56 Processing: Cure Cycles



**Sandwich structure**

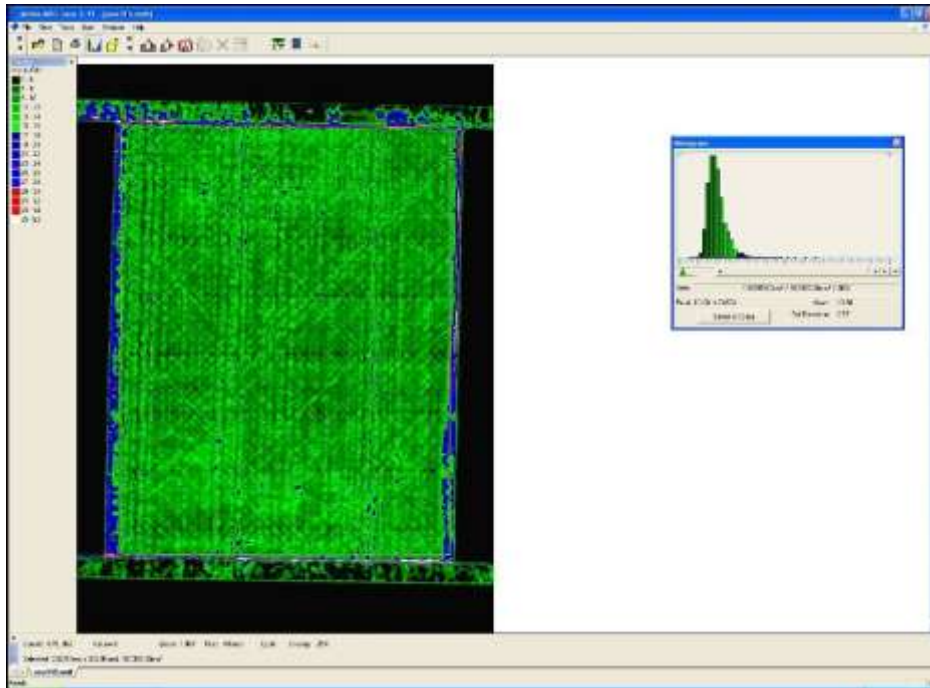


**Monolithic structure**

**Vacuum cycle adapted to part type  
Lower temperature 6 hours at 135°C cycle possible**

# M56 Processing: Typical OOA UD Laminate Quality

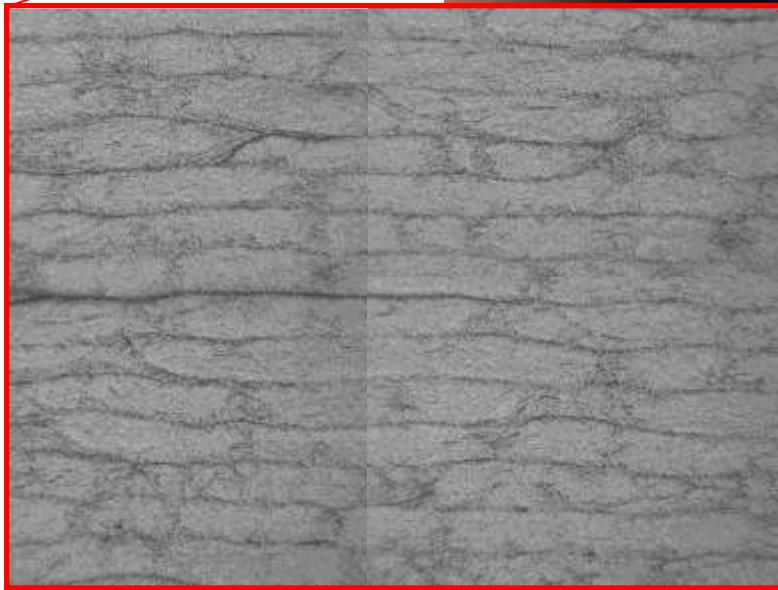
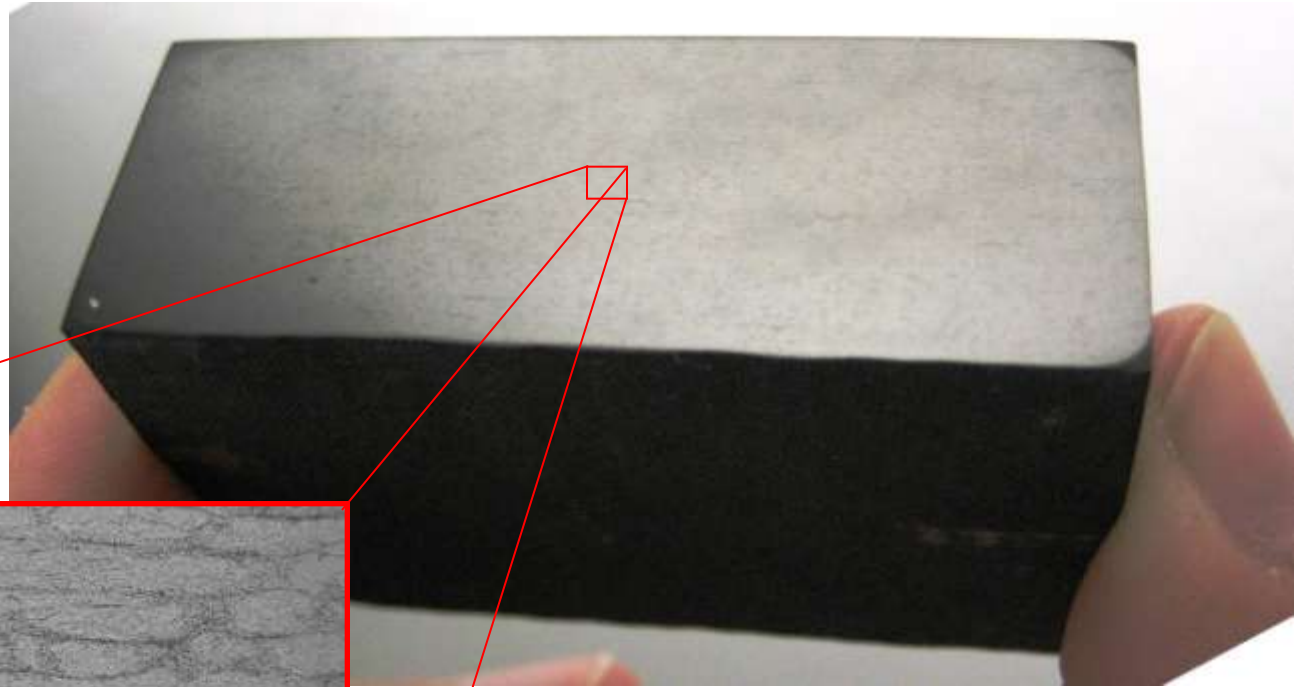
M56/35%/UD268/IMA-12K



Typical porosity < 0.3%

## ***M56 - 80 Ply UD Laminate (20 mm Thickness)***

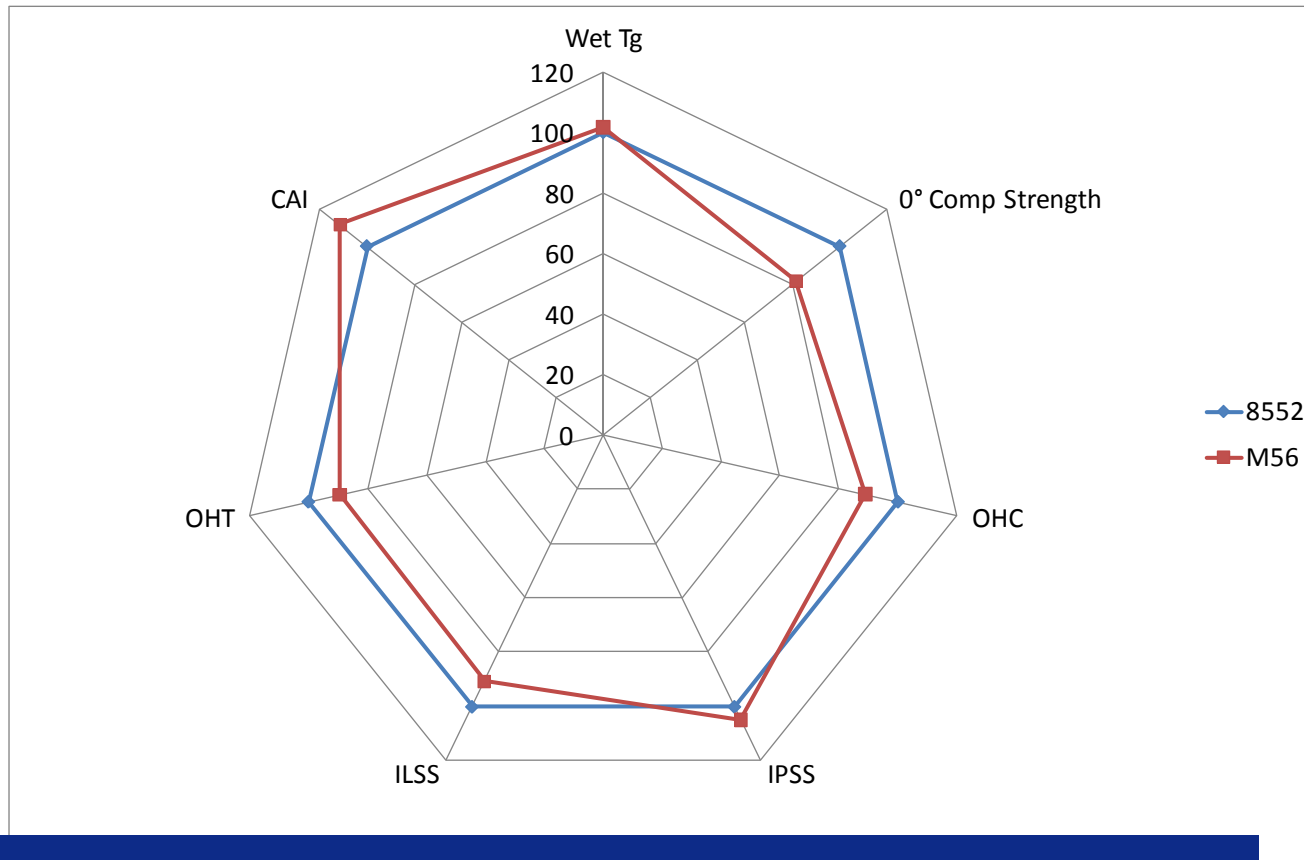
---



**Thick laminates  
possible with  
low porosity**

# Mechanical Performance

M56 mechanical data compared with 8552 autoclave prepreg UD prepreg, 35% resin content, 145 FAW IM7 fibre.



Large mechanical database developed.  
Compares well with 8552 but a little lower in compression.

# ***Demonstrator Parts***

---

## ➤ **Challenges**

- Low porosity
- Complex geometry
- Thin skin over core
- Surface finish
- Automated processes
  - ATL
  - AFP

**Trials have covered several critical processes**

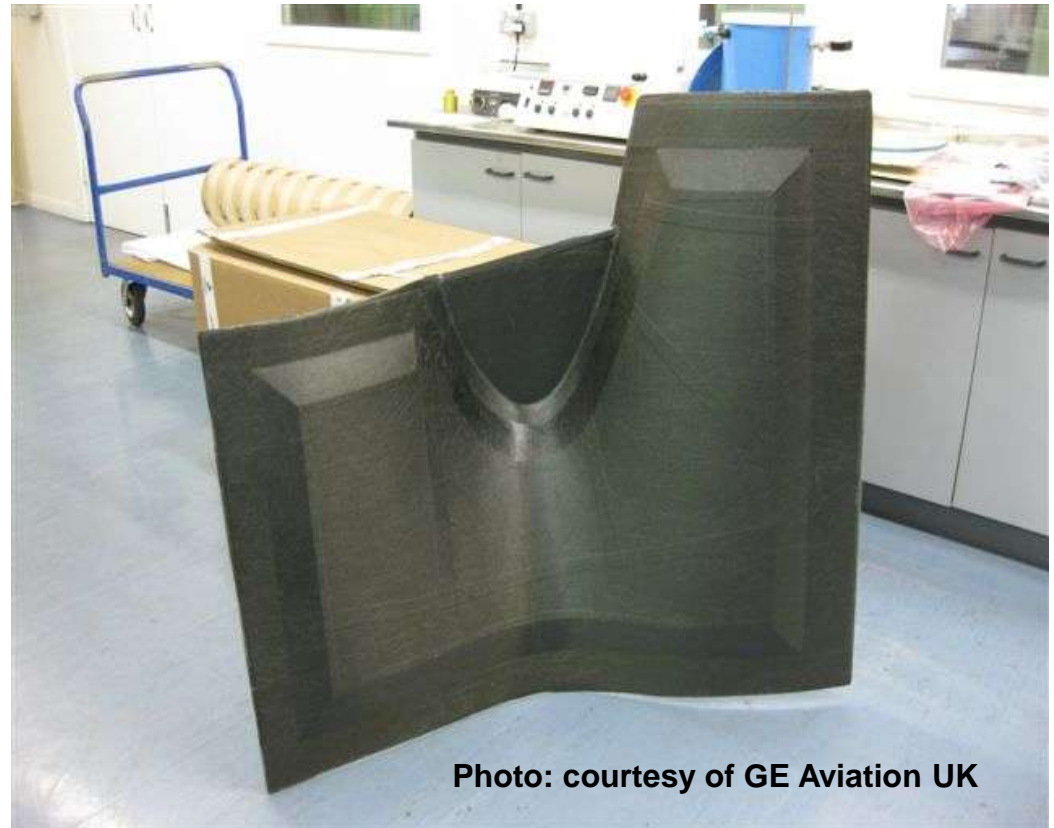
# ***Demonstrator Parts -A320 Fillet Fairing***

## ➤ **Materials**

- M56/40%/280H5/AS4-3K
- 30mm HRH10 core

## ➤ **Feedback**

- Complex shape
- Fully passed water leak test  
(3 ply skin)
- Minimal spring back

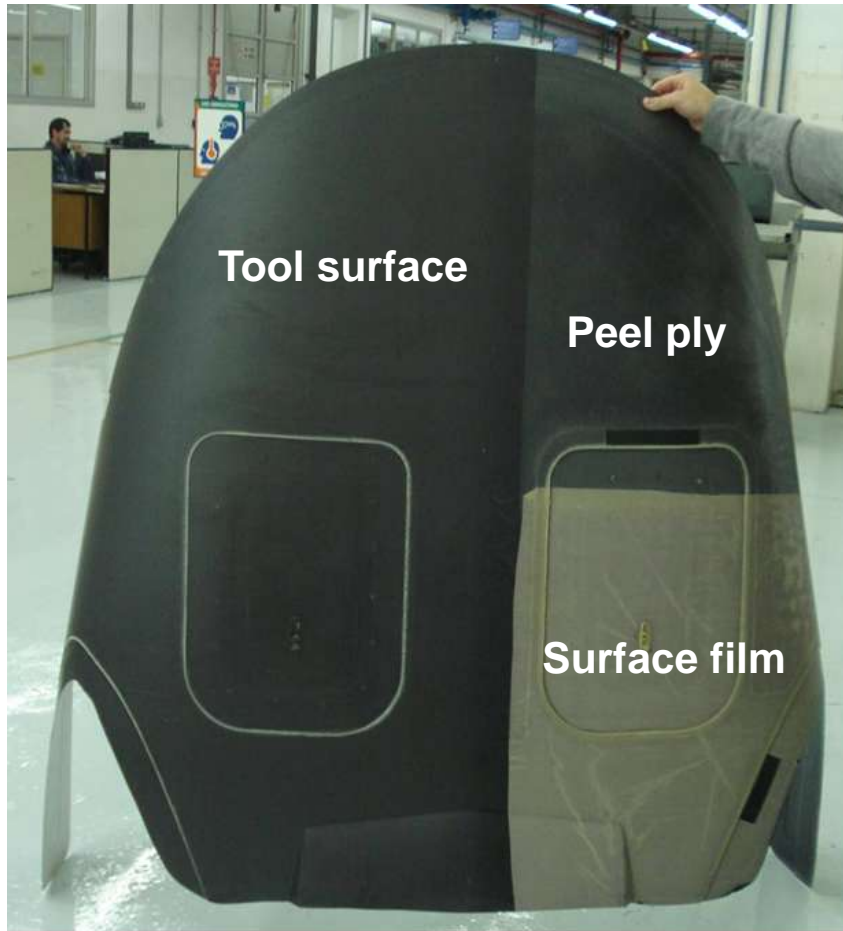


**Sealing of core with good finish particularly effective over complex shape.**



# ***Demonstrator parts – Surface finish***

**Materials: M56/40%/193PW/AS4-3K  
HRH10 25 mm core**



**Excellent surface finish  
without need for surfacing films  
allowing direct painting**

## ***Automated processing***

---

- **M56 UD tapes have successfully been used in ATL and AFP trials with several component manufacturers.**
- **Fully impregnated material is essential for success in automated processes.**
- **Surface breathing results in low porosity parts**

**268g FAW UD tapes  
successfully processed**



Photo courtesy of GKN UK



*M56/35%/UD268/AS7-12K*



Photo courtesy of GKN UK

# ***Conclusions***

---

- **HexPly® M56 was specifically designed for out-of-autoclave processing**
- **Available with a variety of reinforcements**
- **Fully impregnated for ATL / AFP processing**
- **Handle as for 'autoclave' prepregs BUT cure under vacuum in an oven**
- **Suitable for aerospace quality sandwich panels and monolithic laminates**
- **Several demonstrator parts successfully manufactured**
- **M56 material in qualification**
- **Next generation products under development**

**OOA processing can produce high quality parts  
and is gaining acceptance in aerospace**